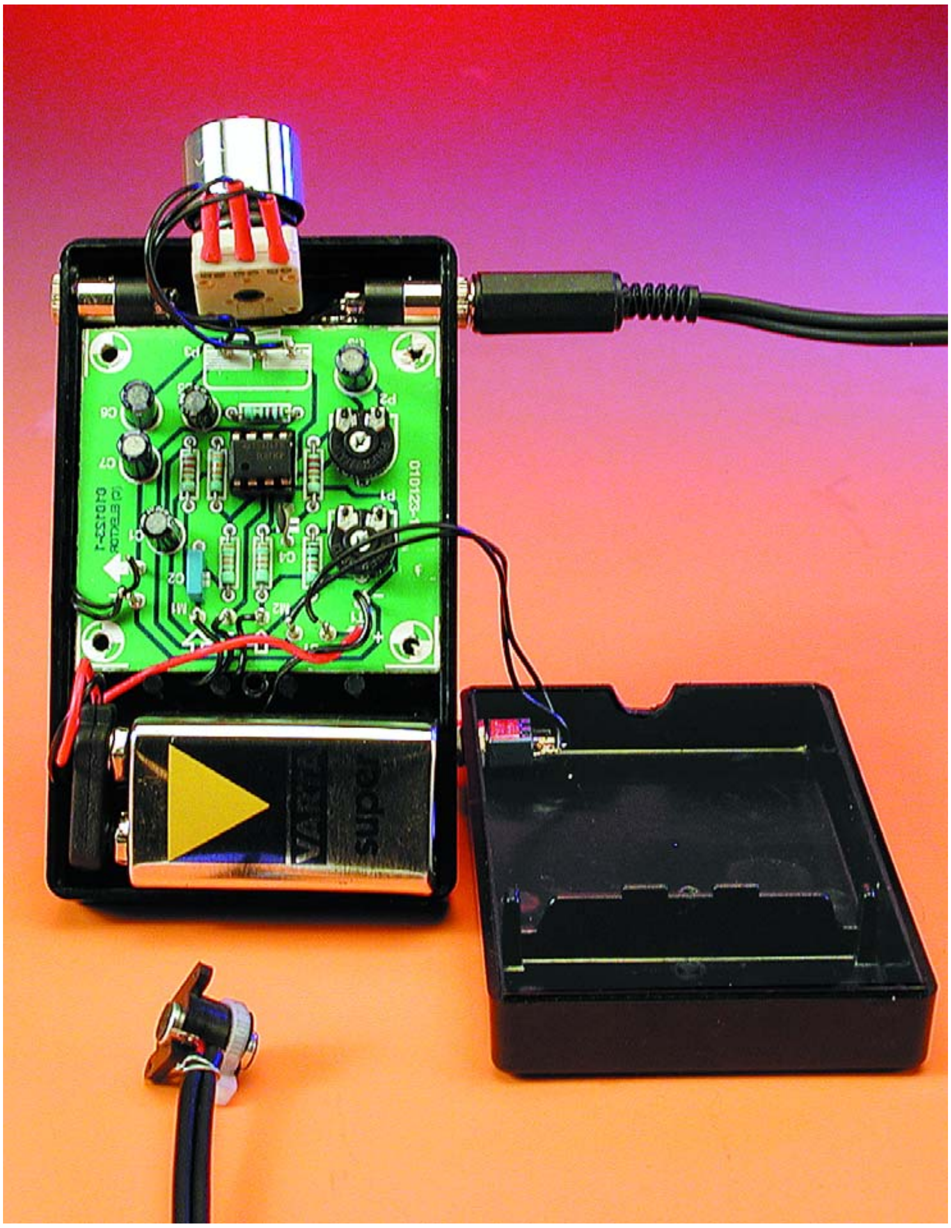
Directional Microphone

for ‘softer’ instruments

design by K. Rohwer

Compared to the other instruments in a band the mouth organ is often not loud enough. Turn up the amplifier, and you risk feedback. What is needed is a microphone with a highly directional response.



Microphones that are equally sensitive in all directions have a spherical, or omnidirectional, response pattern. Such microphones respond to the changes in pressure that represent a sound. Pressure is a directionless quantity, and so a microphone with an omnidirectional response pattern can also be used as a pressure transducer (**Figure 1a**).

As an alternative to this there is the pressure gradient transducer. Pressure gradient, the derivative of pressure with respect to distance, is a directed quantity: it reaches a maximum in the direction of the sound source, is zero perpendicular to that direction, and in the opposite direction is again at a maximum, but with opposite sign. A microphone which is a pure pressure gradient transducer has a response that depends on the angle to the sound source that resembles a figure-of-eight (**Figure 1b**).

Most microphones have a characteristic that lies between these two extremes. By mixing the omnidirectional response and the figure-of-eight response in various proportions, a response maximum in one particular direction can be achieved, the so-called cardioid characteristic (**Figure 1c**). If a small maximum in the direction opposite to the sound source is acceptable, the maximum in the direction of the sound source can be made more pronounced, resulting in a so-called supercardioid pattern (**Figure 1d**).

Two spheres =one supercardioid

How do we build a pressure gradient transducer? Take two pressure transducers, arrange them a (small) distance apart — or else it won't work — and form the difference between the two output signals. Any microphone capsule will do for a pressure transducer, as long as the sound cannot reach the back of the membrane: for example, an electret microphone capsule will work.

The distance between the two capsules must not be too great. If half the wavelength of the sound is equal to the distance between the two membranes, the two pressure signals will be exactly 180° out of phase. At the differential amplifier the signals cancel one another out rather than reinforcing one another. At higher frequencies, therefore, the microphone becomes less directional.

The author has developed a microphone along these lines, with a suitable preamplifier that allows the signals from the two capsules to be mixed in variable proportion: the directional characteristic is adjustable.

Figure 2 shows the construction of the microphone. The microphone capsules are fitted into a rubber tube (which came with the capsules), cut lengthways with a craft knife. A small plastic disc, cut out using an office hole punch, serves to isolate the electrical connections from one another. The front surfaces of the microphone capsules are at a distance of about 15 mm from one another, which gives a cutoff frequency of 11 kHz for the directional characteristic. Above 11 kHz the microphone is also sensitive to feedback, and so it makes sense to turn down the treble control on the amplifier.

The arrangement can be built into a miniature enclosure as shown in **Figure 3**. The enclosure has been specially modified: both sides have been perforated to allow the sound to get to the two microphone capsules easily. The cable entry on the left-hand side is fixed to the enclosure via a length of aluminium angle extrusion, and the microphone capsule unit therefore sits freely between two layers of foam rubber. A third thin strip of foam rubber is fitted in front of the microphone to protect it in the direction of its maximum sensitivity.

The author uses his microphone with a

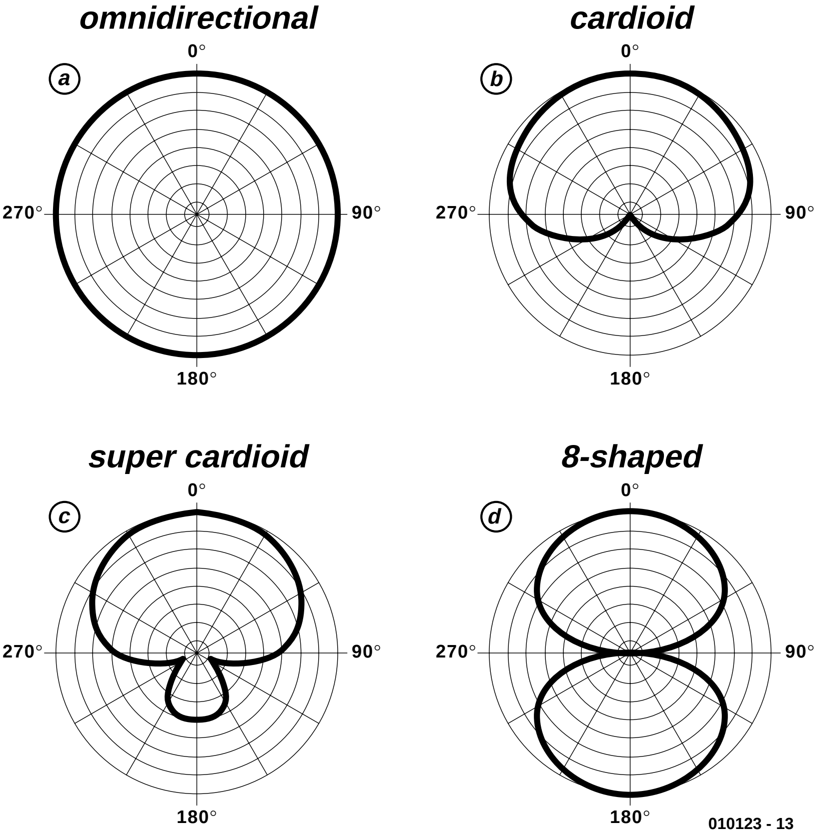


Figure 1. From omnidirectional to supercardioid: a range of microphone characteristics.

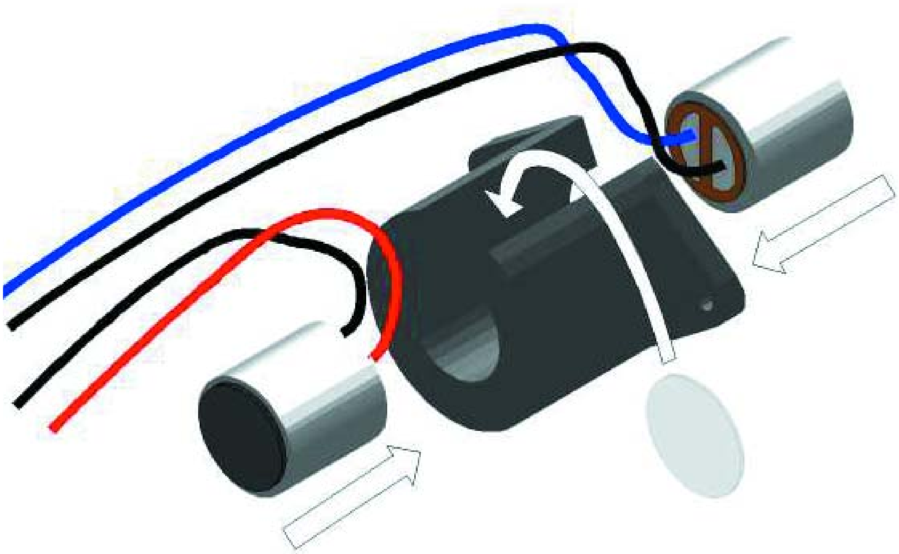


Figure 2. The two microphone capsules, fitted opposite one another in a rubber tube.

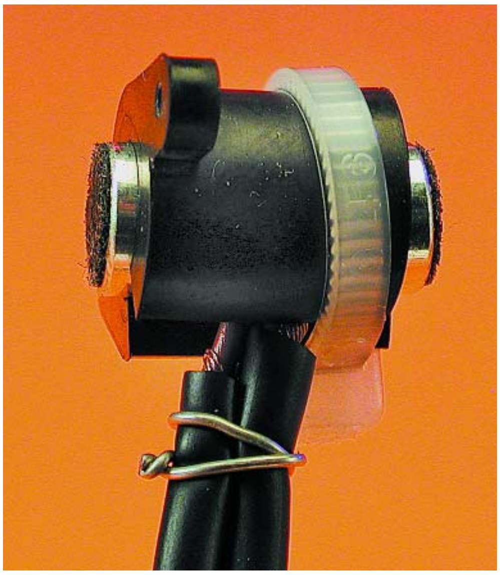


Figure 3. The author's microphone enclosure with freely-hanging microphone.

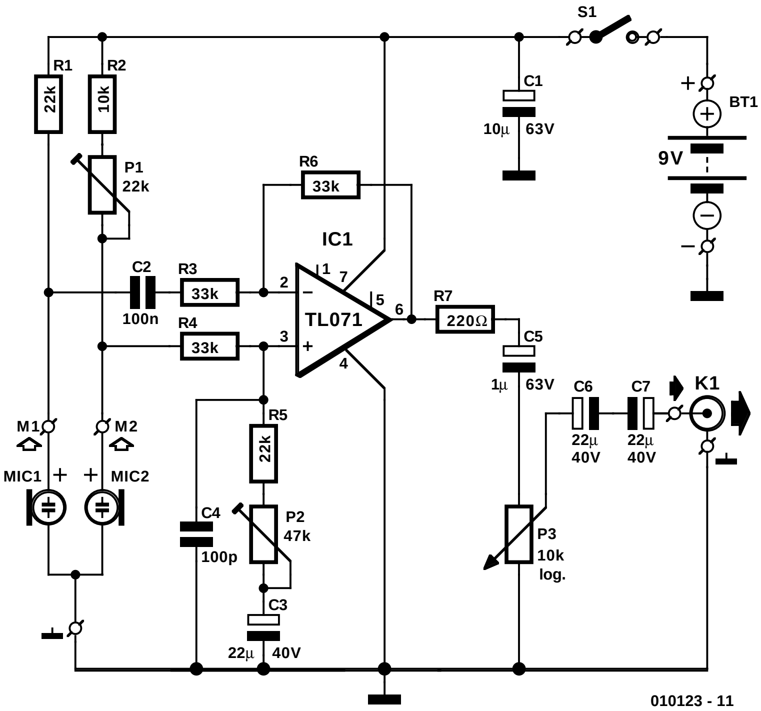


Figure 4. Circuit of the differential microphone amplifier.

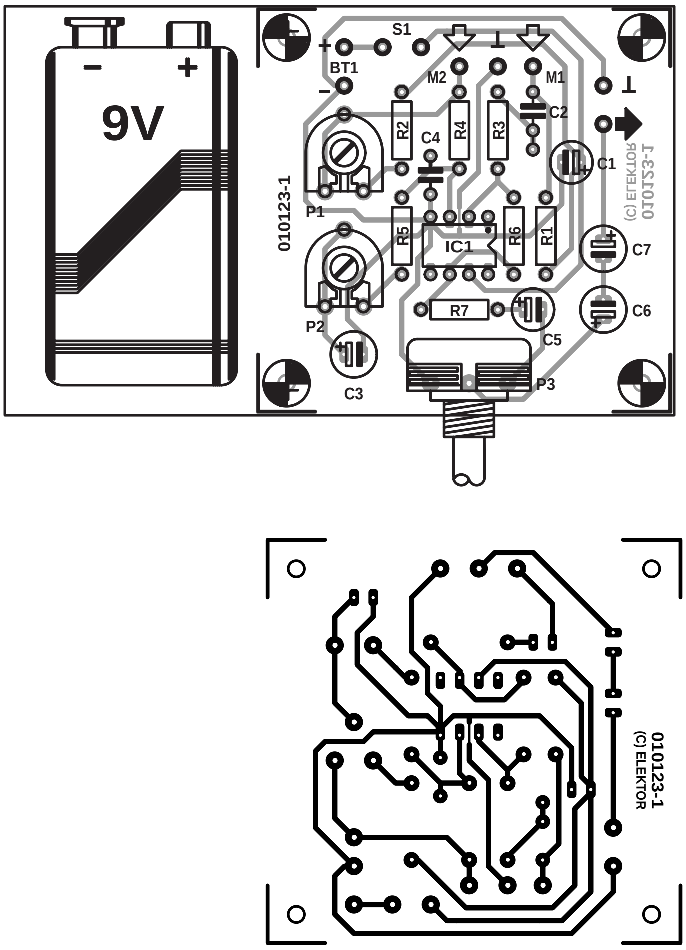


Figure 5. The circuit board is fitted into an enclosure with belt clip and battery compartment.

COMPONENTS LIST

Resistors:
R1,R5 = 22kΩ
R2 = 10kΩ
R3,R4,R6 = 33kΩ
R7 = 220Ω
P1 = 22kΩ preset
P2 = 47kΩ preset
P3 = 10kΩ potentiometer, logarithmic law, miniature mono type

Capacitors:
C1 = 10µF 63V radial
C2 = 100nF
C3,C6,C7 = 22µF 40V radial
C4 = 100pF
C5 = 1µF 63V radial

Semiconductors:
IC1 = TL071CP*

Miscellaneous:
Bt1 = 9V PP3 battery with clip-on connector
MIC1,MIC2 = miniature condenser (electret) microphone capsule with rubber holder (e.g. Monacor/Monarch type MCE2000)
3.5mm stereo jack socket or 5-way DIN-socket, chassis mount*
K1 = 6.3mm mono jack socket with integral isolated switch, for chassis mounting
Enclosure with battery compartment (and belt clip), size approx. 102 × 61 × 26 mm

PCB layout available from Free Downloads section at www.elektor-electronics.co.uk)

* see text

mouth organ and has therefore made a couple of special modifications. The two countersunk screws in the aluminium angle section hold a Velcro band to the outside of the case, making it easier to hold the microphone comfortably with two fingers. It also became clear that some of the holes had to be closed up in order for the microphone not to pick up the sound of the player breathing through the nose. A foam headphone pad was therefore fitted to the front of the enclosure to dampen the sound of the air flowing over the sharp edges of the holes.

The microphone capsules are connected, observing polarity, to the central cores of a two-core screened microphone cable, the other two connections both being connected to the screen. A 3.5 mm stereo jack is fitted to the other end of the cable.

For improved ruggedness, for use in a studio for example, 3.5 mm jack plugs are not good enough. It is better to use a five-pin DIN connector, wiring pairs of contacts in parallel (ground being taken both to pin 2 and to the screen of the plug).

The microphone preamplifier

The circuit of the differential preamplifier is shown in **Figure 4**. Electret microphone capsules have an internal FET impedance converter and behave as a current source of about 250 µA. This value can vary wildly, even between examples of the same type. The current is modulated by the sound signal, and again the sensitivity can vary widely from device to device. The microphones' series resistors, R1 and the R2/P1 combination, are chosen so that about half the supply voltage is dropped across them. This may not be exactly the case for MIC1, and so C2 is provided to remove the DC component from the input to the amplifier circuit. The series resistance for MIC2, on the other hand, sets the DC offset of the whole circuit, and is adjusted using P1 so that the output voltage of the op-amp is equal to half the supply voltage. The signals from the two microphones are taken to the op-amp, which is connected as a differential amplifier. The author used a type TL071 here, but we also recommend pin-compatible alternatives such as the OPA181GP, TS921IN or OPA350PA rail-to-rail op-amps in order to squeeze the last milliamp-hour of capacity out of the battery.

The signal from MIC2 can be attenuated or boosted using P2 in order to compensate for variation between the microphone capsules. This also affects the directionality of the unit. If R5 plus P2 could be made a short circuit, MIC2 would have no effect and just the omnidirectional characteristic of MIC1 would remain. On the other hand, if MIC1 and MIC2 were identical, and R5+P2 were made equal to 33 kΩ, the figure-of-eight characteristic would result. In between we can obtain the cardioid and supercardioid characteristics. C4 prevents the circuit from going into oscillation.

At the output we have volume control P3 followed by (imitation) bipolar electrolytic C6, which isolates the circuit from any phantom power supply that might be present. A 6.3 mm jack socket, as commonly used in PA applications, serves as the output connector. The jack should have an integrated, isolated switch which can be used to activate the unit only when the jack is plugged in. This saves a power switch, which is all to easy to forget — leaving the battery flat when the unit is next used.

The whole unit is readily assembled on the circuit board, whose layout is shown in **Figure 5**, and easily fitted into a suitable enclosure with battery compartment. P2 should be fitted with a spindle which can pass through a suitably drilled hole in the enclosure. This allows easy adjustment of the directional characteristic. Take care to ensure that the construction is sturdy and that the sockets are wired tidily: you do not want to suffer a loose connection in the middle of a performance!

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